

The cause of the lowering of the channel is not far to seek. The sand of which the river bed is composed was long ago found to be of excellent quality for concrete work and almost 200,000 cubic yards are removed annually in the immediate vicinity of the gage and for a distance of half a mile below it for this purpose. Evidently this has lowered the control of the stream channel for some distance in this particular section of the river. In the absence of other gage readings nearer than Wamego, 35 miles upstream in an air line, and Bonner Springs, about the same distance below, neither of which has a record covering more than a few years, it is not possible to state how far this lowering effect has extended, but rating curves of discharge for the past five years at those places do not suggest any material change in the river bed, also there has not been much sand-dipped out of the river at either point.

It is difficult to estimate just what effect this lowering of the river channel at Topeka will have on high stages. Absence of high water during the last two years has

prevented obtaining discharge measurements above 11 feet, but the approach of the rating curve of 1922 toward that of 1917 at higher stages indicates that at flood stage, 21 feet, there will not be much difference between the present volume of water passing the gage and the amount that passed at the same stage several years ago. However, the matter is worth investigation, especially as the decrease in height of the stages is a progressive affair and may go several feet farther in the next few years.

An immediate effect of the lowering of the stages is that it has been necessary to tear out the concrete floor of the well in which the float of the self-registering gauge at Topeka operates and lower it more than a foot at a considerable expenditure of time and money. When the gauge was installed five years ago it was assumed that it would register any low stage that might occur and this was borne out by past records, but on several occasions in the last year of the record the river was so low the float rested on the bottom of the well.

### SNOWFALL AND THE RUN-OFF OF THE UPPER RIO GRANDE.

By CHARLES E. LINNEY, Meteorologist.

[Weather Bureau Office, Santa Fe, N. Mex., December 21, 1922.]

#### SYNOPSIS.

The run-off which appears in the upper Rio Grande is almost wholly derived from the melting of snow that falls on the elevated parts of the drainage basin in Colorado and New Mexico. Statistics are presented showing the mean monthly and annual snowfall as derived from an average of 10 stations in Colorado and 12 in New Mexico for the period of years, 1909-1922. The measured discharge of the Rio Grande, near Buckman, N. Mex., as determined by the United States Geological Survey is also given for the corresponding period and for earlier years.

The average annual snowfall is 97 inches. Assuming that the equivalent of the snow was 0.08 inch of water per inch of snow, and assuming further that there was no loss by diversion or otherwise and that but 29 per cent of the precipitation was measured as run-off, that amount of snowfall would correspond to 1,332,000 acre-feet for the area above Buckman, N. Mex. This amount corresponds very closely with the average run-off for the entire term of years but is somewhat below the average for the 13 years, 1909-1922. The uncertain factors in the above approximation are the water content of the snow, diversion, and other losses which can not easily be approximated.

In a consideration of the snowfall in connection with the run-off of the upper Rio Grande it is obvious that the calendar year is unsuited to the discussion or tabulation of data; rather should the year conform, in fair measure, to the natural cycle of snowfall and melting, and an effort be made to choose a period which will most nearly set apart the run-off which can be expected from snow, the resulting water to be measured as the stream discharge. After some consideration of the probable date when practically all snow water has found its way into the stream, I have chosen a year (or probably better, a cycle) to begin with the first of August. But in this choice it is admitted, of course, that there is an intermingling of rain and snow. It is thought, however, that the date chosen sets forth a cycle that is least affected, except one that would completely eliminate the late spring, summer, and fall run-off. In some of my figures I have done this, setting forth the results from snow alone, which will be apparent in the discussion.

#### THE PRECIPITATION OF THE DISTRICT.

The precipitation of winter which occurs over the southern Rocky Mountains pertains to the Pacific weather type, somewhat obliterated and diffused by the distance from the ocean. The humid winds of the Pacific are drawn across the region by the influence of low-pressure areas over regions near or remote, and

step by step in its journey eastward the atmosphere discharges its moisture over the graduated plateau and mountain ranges, till it reaches the crowning peaks where occurs its maximum fall, as, for instance, around the rim of the San Luis Basin in Colorado and over the great crests of the Sangre de Cristo in New Mexico, between Taos and Colfax Counties, attaining there a maximum snowfall of probably 300 inches annually. Altitude has much to do with this; in fact it is probably the most important factor, next to the eastward movement of the moisture-bearing winds. General Greely gives the following table of altitude areas and precipitation for Colorado and New Mexico.<sup>1</sup>

State.	Elevations (feet).	Area (square miles).	Cubic miles, precipitation.	Average precipitation (inches).
Colorado.....	4,000 and less.....	8,773	1.5	11.15
	4,000 to 5,000.....	18,031	3.2	11.78
	5,000 to 7,000.....	31,314	6.1	12.74
	7,000 and over.....	45,885	9.2	13.12
Whole State.....		104,000	20.0	12.61
New Mexico.....	4,000 and less.....	6,996	1.1	10.14
	4,000 to 5,000.....	34,407	6.1	11.59
	5,000 to 7,000.....	57,503	12.4	14.13
	7,000 and over.....	22,300	5.6	16.34
Whole State.....		121,200	25.2	13.62

In other words, considering New Mexico only, 71 per cent of the possible precipitation of the State occurs above 5,000 feet upon 66 per cent of the land area, while over the really worth-while elevations for the storage of snow (7,000 feet and over) only 22 per cent of the precipitation occurs upon less than 20 per cent of the land area. The ratio is somewhat greater for the Rio Grande drainage, since but a small part of it is below 5,000 feet, and a relatively large part is above. A very considerable part of the 22,300 square miles of the State which is above 7,000 feet is within the drainage area of the Rio Grande, but not within the district under discussion, which includes only the northern part of New Mexico, an area of approximately 6,400 square miles, and the southern part of Colorado, an area of approximately 7,300 square miles.

<sup>1</sup> Irrigation and water storage, Ex. Doc. No. 287, 51st Cong., 2d sess., 1891.

Some idea of the increase of precipitation with altitude can be gained from a report of the late Robert R. Briggs, of the Arizona climatic service, who compiled a table of July records from 104 stations for 18 years, as follows:<sup>2</sup>

*Average for 18 years of July rainfall in Arizona at different altitudes.*

Number of stations.	Elevation (feet).	Average rainfall (inches).	Average number of rainy days.
8	Below 1,000.....	0.33	1
16	1,000 to 2,000.....	0.63	5
11	2,000 to 3,000.....	2.72	10
16	3,000 to 4,000.....	2.79	10
20	4,000 to 5,000.....	3.95	14
16	5,000 to 6,000.....	4.05	12
10	6,000 to 7,000.....	5.01	17
5	7,000 to 8,000.....	5.70	21
2	8,000 or above.....	7.12	29

#### SNOWFALL AND WATER CONTENT.

Freshly fallen snow, as shown by our experience in the western mountain country, has a water equivalent of from 3 to 10 per cent, mostly around 5 to 8 per cent, according to altitude, temperature, time of day of the fall, season, etc. In consistency it varies from the light feathery type, the powdery, little pill, or small hail type, to the wet clinging type (with many intervening kinds). The water equivalent of the first is probably 3 to 5 per cent, the second 5, 6, or 7 per cent, and the third 8 to 10 per cent. Accumulated snow, however, rapidly becomes of higher water content as it is compacted by the weight of the upper layers in the recurring falls of snow, aided by absorption of the sun's rays, settling by wind, and more or less heat even from the earth itself. It is possible also that some water is added by condensation from the atmosphere direct, especially in the higher districts where cloud formations drag across the mountain tops and fogs are thus much more frequent. Tests of snow which has accumulated for a considerable time, show that the water content goes upward to 20, 30, 40, and even 60 per cent of its volume, becoming almost ice.

Various snow samplings and snow surveys have been made in the western mountain country and have shown water content from 20 to 40 per cent or greater. Mr. H. S. Cole, in measuring the drifts in Nevada at 9,000 feet and in snow to a depth of 14.5 feet found as high as 46 per cent of water, and in another of 13.5 feet, found it contained 38.4 per cent water. Measurements in Maple Creek Canyon in Utah, in depths averaging from 23 to 52 inches, showed 22 to 35 per cent water content. Measurements in Big Cottonwood Canyon, in depths up to 9 feet, showed a water content from 33 to 48 per cent, and one at 11.5 feet, in a snow slide, showed up to 56 per cent. When the season of rapid melting is at hand the proportion may easily rise to 50, 60, 70, and even 85 per cent, really becoming ice banks.

Mr. Alexander McAdie, in an account of the very great snowfall at Summit, Calif. (the greatest in the United States, although at an altitude of only 7,017 feet), has shown that 86 per cent of the annual precipitation occurs as snow, averaging 443 inches, or about 48 inches of water. The snowfall has risen as high as 783 inches, and has never fallen below 153.8 inches in many years' record. The greatest depth (783 inches) amounted to 80.1 inches of water and the least (153.8 inches) to 21.8

inches of water. A test of the water content in this remarkable region showed at the surface 34 per cent water, at 64 inches, 45 per cent, and at 174 inches 59 per cent.

#### INFLUENCING FACTORS.

The character of the watershed and the local environment have much to do with the accumulation of snow and the resulting run-off configuration, topography, vegetation and forestation (or the lack of these), character and kind of soil or rock, and many other things enter into the accumulation of snow, and in greater or less degree the run-off therefrom. When melting is active in the spring (and even at times during the winter, when warm rains fall over lower levels) a fairly heavy rain may result in sudden and unusually large run-off. On the other hand, a cold spring, with the season warming up slowly, may result in long drawn out run-off, large local absorption, and even the actual elimination of what earlier had promised to be a fair run-off. Streams like the Rio Grande, where the spring run-off is so largely dependent upon the accumulation of snow, respond quickly to these limiting factors. Even changes in the character of the watershed by agricultural and lumbering pursuits have an effect. These and other things change the character and amount of flow from season to season.

#### EARLY VIEWS OF THE RUN-OFF.

In a discussion of the relation between precipitation and the run-off, the following appears:<sup>3</sup>

Comparison between the precipitation and run-off for the various parts of the United States has been made by Henry Gannett, of the United States Geological Survey, who found that where the annual precipitation is less than 20 inches no definite relation exists, as apparently the needs of vegetation require that much. With less than this amount of precipitation the run-off will depend almost entirely on the intensity of the rainfall rather than upon the total amount. Short violent storms will cause a comparatively large percentage of the precipitation to run off as surface water, whereas the same or even larger precipitation occurring as gentle showers may have practically no run-off, the water finding its way into underground channels, evaporating, or being absorbed by vegetation. As there are only a few points in the Rio Grande Basin where the annual rainfall exceeds 20 inches, it is seen that no definite relation exists between precipitation and the run-off. Any possible relation is still further complicated by diversion of the waters for irrigation and by the large nonproducing areas in the upper parts of the drainage area.

That these conclusions were probably overdrawn appears to be shown by the fact that later Mr. Gannett estimated that a mean annual run-off of 3 inches was to be expected from the lower valleys and mesas of the upper Rio Grande in New Mexico and of the San Luis Valley of Colorado, increasing to 10 inches or more over the higher mountain areas of the San Juan, Culebra, and Sangre de Cristo Ranges. In other words, he estimated that about one-third of the annual precipitation reached the streams, since the annual amount over the lower valleys and mesas of northern New Mexico and the San Luis Valley of Colorado averages from 8 to 10 or 12 inches, increasing to 15, 17, or 20 over the foothills, and to 25 or possibly 30 inches over the higher mountain areas, a probable average for the district under discussion of about 15 inches annually. This is nearly equally divided between rain and snow. At the Wagon Wheel Gap experiment station, the results gave approximately 50-50 basis, and the run-off, from the several years record, averaged 29 per cent.<sup>4</sup>

<sup>2</sup> Variations in precipitation as affecting water works engineering. Am. W. W. Assoc., 35:0, 85, 86. 1916.

<sup>3</sup> U. S. G. S. Water Supply Paper No. 353, p. 24.

<sup>4</sup> MO. WEATHER REV. SUPPLEMENT NO. 17, p. 32.

Year.	Precipitation.	Run-off.
	Inches.	Inches.
1912.....	21.30	8.4
1913.....	18.63	4.8
1914.....	22.64	5.6
1915.....	19.97	5.4
1916.....	22.71	5.6
1917.....	22.88	5.6
1918.....	18.90	3.2
Mean.....	21.90	6.1
Percentage.....		29.0

The remainder of the precipitation, it was estimated, was disposed of as follows: Seventeen per cent lost by interception, 18 per cent lost by transpiration, and 36 per cent loss by evaporation.

#### MELTING SNOW.

Snow occurs from September or October to April or May, and the period from about the 1st of October may properly be considered as the period of storage, when stream flow should be reduced to a minimum. The snow of September rarely lies, but is lost by evaporation, melting, etc., and a considerable part of the October snow is lost in like manner. Little of it, however, really reaches the streams, except possibly later as underground water. Snow, of course, comes earlier and lasts longer in the high altitudes, and disappears earliest from the lower levels and the south slopes. North slopes in fact may be, and often are, over limited areas permanently covered with snow. Snow does not begin to accumulate on south slopes until well into cold weather and goes with the first increasing warmth. It begins to melt on the south slopes in February, but the resulting water does not quickly become available for stream flow, or even to replenish ground water, since the water first percolates into the snow itself, and does not reach the soil till a later stage of the melting cycle. Melting is greatly affected by slopes and air temperature, and on south slopes melting is often completed before it is even fairly started on north slopes or in the deep canyons. Yet these south slopes contribute little to the actual run-off, the moisture mostly going to underground flow.

Experiments indicate that the flow of water from melting snow is determined by gravity, and its speed is conditioned upon the porosity of the snow directly underneath. Professor Henry concludes that the run-off from melting snow must reach the stream largely through underground channels. When the snow melts slowly the opportunity for percolation into the soil is large, and any surface run-off of consequence should not be expected until the time of maximum melting, when the surface run-off from north slopes is probably greater than ever happens in the case of rainfall. This may be due to the fact that the shed is then much like a roof, probably with frozen soil and practically no percolation possible.

Snow melts in appreciable measure when the shade temperature rises to or above freezing. Melting progresses in somewhat increasing ratio as the temperature rises, varying, however, with the changing seasons, the winds, the humidity, cloudiness, etc., as well as the character of the snow itself and the character of the soil or rock beneath. On the other hand, melting is checked and often largely prevented by the recurrence of cold. As an example of almost complete absorption it may be noted that there was practically no run-off in the spring of 1904, and but little in the springs of 1899, 1902, and 1918.

#### THE RIO GRANDE RUN-OFF.

One might almost conclude, as we have earlier quoted, that the run-off does not bear any relation to the snowfall, but as a matter of fact they are closely related, so closely that the plotted curve of the one can almost be substituted for the other. A number of rather ingenious formulæ have been compiled in attempts to express this relationship. Among the most recent is that of Mr. Adolph F. Meyer. Others have attempted it, but Engineer Birkenbine concludes that<sup>2</sup>—

Such formulæ do not form a reliable means of building up a chronological monthly record of run-off from precipitation records alone. Their employment is strictly limited to sheds for which long and accurate monthly meteorological records of precipitation, temperature, etc., are compiled \* \* \*. Under the circumstances the run-off computed with tentative coefficients may be compared with the corresponding actual run-off, where known, and the first assumption as to the proper watershed coefficient modified in the light of this comparison.

Mr. Meyer himself says (p. 1060, Trans. Am. Soc. C. E., Vol. LXXIX):

Let it be understood at the outset that the writer does not claim to have discovered a method of computing daily or even monthly run-off from rainfall and other physical data which obviates the necessity for stream measurements. He believes, however, that he has found a method of computing the annual run-off from widely different watersheds with considerable accuracy, and of computing a reasonable distribution of such run-off through the various months of the year for most of such watersheds.

Averaging a fair representation (24) of the snowfall stations over the Rio Grande watershed north of the river station at Buckman, gives an average seasonal snowfall of about 97 inches, and if this were on the ratio of 0.08 inch of water to each inch of snow the result would be 7.76 inches precipitation; if, however, it were in the proportion of 0.07 inch to each inch of snow the result would be 6.79 inches of precipitation. On the basis of 29 per cent run-off, which actually occurred at the experiment station at Wagon Wheel Gap, Colo., the first ratio would give 2.25 inches run-off, while the second would give 1.97 inches. In the first instance a consideration of the acreage would show a full run-off of 1,332,000 acre-feet, not allowing anything for loss, diversion, use or other items, a figure which is not far from the actual annual average run-off, as shown through a period of 23 years. If, however, the second ratio were used as the amount of water which would find its way to the stream, the total run-off would be 1,166,300 acre-feet, an amount which is somewhat below the average annual run-off and in excess of the average spring run-off. These figures are not given as a formula, but simply to show that an approximation can be made and that there is hope of a fairly correct formula in time.

#### THE DATA USED.

A consideration of the data given discloses the great height and flow that occurs in the months of May and June—from 60 to more than 80 per cent of the spring run-off occurs in these two months, or about one-half of the average annual flow. At times it has been phenomenal, thus in 1920, 1,500,000 acre-feet passed the Buckman station in the two months. An average of almost 900,000 acre-feet occurs between the first of March and the last of June.

The greatest annual flow thus far noted was 2,461,600 acre-feet in 1904-5, while during the prior year the amount was only 269,500 acre-feet, the smallest known record. The stream was dry that year below Albuquerque for many months. The greatest monthly flow was 860,000 acre-feet in May, 1920, and the least (for a full month) 10,100 in August, 1900.

On the snow side of the data (since 1909) the winter of greatest fall was that of 1915-16, closely followed by 1911-12, when the station at the old mining camp of Anchor measured 483 inches—over 40 feet of snow. The least seasonal fall was in the winter of 1917-18, when few stations over the watershed had 100 inches, and the Anchor station had but 205 inches.

*Explanation of the tables.*—Table 1 contains the mean monthly snowfall for the upper drainage basin of the Rio Grande, viz, those areas contained within the States of Colorado and New Mexico. The figures in the table are the means of individual stations throughout the drainage basin in both States. The number of stations in Colorado averaged 10, in New Mexico 12, and these numbers were fairly constant throughout the period of measurement.

Table 2 contains the monthly discharge measurements as made by the water resources branch of the United States Geological Survey, near Buckman, N. Mex. The figures in the units and tens places have been rounded off so that the figures in the table represent hundreds of acre-feet.

Table 3 is a summation of annual discharge in thousands of acre-feet and the average snowfall for the upper part of the watershed in inches and tenths. Snowfall data for the early part of the run-off period are lacking.

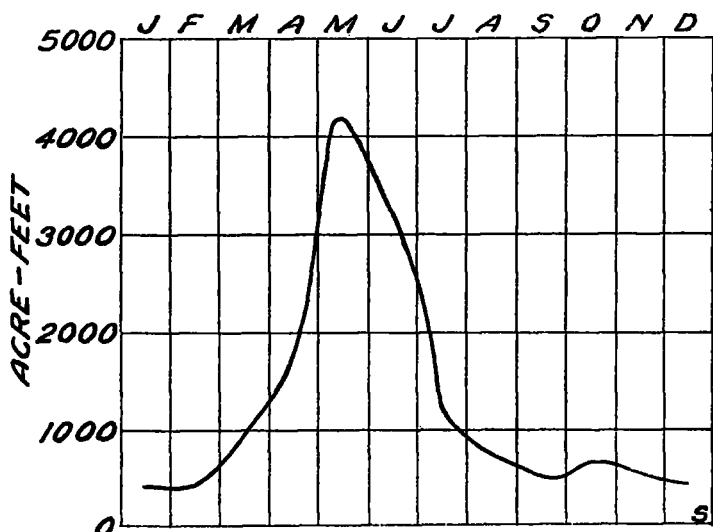


FIG. 1.—Discharge of Rio Grande at Buckman, N. Mex. (acre-feet).

TABLE 1.—Average monthly snowfall, upper Rio Grande (inches and tenths).

COLORADO.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Season.
1909-10.....	1.5	6.9	21.8	21.4	12.9	11.8	7.8	9.7	2.4	0.0	96.2
1910-11.....	0	7.9	7.6	12.3	12.4	31.0	9.7	6.2	0.5	T.	87.6
1911-12.....	0	10.3	12.0	15.4	5.5	10.5	33.8	16.4	4.2	1.6	109.7
1912-13.....	0.3	10.1	3.1	6.7	11.3	19.1	14.0	7.6	0.1	T.	72.3
1913-14.....	4.9	3.3	11.6	22.2	16.5	8.4	9.6	15.1	3.5	0.1	95.2
1914-15.....	1.0	5.2	0.4	15.4	12.7	23.0	7.8	16.7	12.7	0.5	95.4
1915-16.....	0.8	1.7	7.8	22.6	36.6	8.3	14.8	20.0	2.5	0	115.1
1916-17.....	T.	6.9	4.2	18.0	18.3	16.5	13.9	27.9	15.7	0	121.4
1917-18.....	0.6	1.6	4.0	1.7	23.1	14.2	17.0	5.5	1.2	0	68.9
1918-19.....	0	3.4	23.5	20.3	2.0	15.9	17.6	6.6	1.2	0	90.5
1919-20.....	0.4	11.8	25.4	13.2	8.6	18.0	16.0	27.0	5.0	T.	125.4
1920-21.....	0.3	30.7	4.9	17.5	12.7	9.4	11.2	20.5	2.9	0	110.1
1921-22.....	0	3.3	4.3	15.1	30.4	14.2	21.1	8.0	5.9	0.2	102.5
Average..	0.8	7.9	10.0	15.5	15.6	15.4	14.9	14.4	4.4	0.2	99.1

NEW MEXICO.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Season.
1909-10.....	0.6	3.8	15.6	19.8	13.4	15.1	7.1	7.5	1.5	0.0	84.4
1910-11.....	0	7.5	6.8	11.9	11.1	29.3	9.0	4.2	0.5	0	119.3
1911-12.....	0	9.6	16.0	14.4	8.0	10.4	36.5	19.5	6.3	0.6	83.7
1912-13.....	0.1	6.5	4.5	6.6	13.7	25.3	18.7	8.2	0.1	T.	103.3
1913-14.....	5.4	1.5	11.2	27.9	13.0	9.0	10.9	19.0	5.4	T.	109.8
1914-15.....	0.5	5.3	0.3	18.7	15.0	23.5	12.0	15.4	15.7	2.9	122.2
1915-16.....	0.4	1.2	7.2	20.4	44.9	7.5	18.1	19.9	2.6	T.	113.3
1916-17.....	T.	4.7	2.0	10.5	13.4	16.6	14.4	21.2	19.3	0	70.2
1917-18.....	0.2	0.9	2.2	1.1	25.2	15.2	17.0	10.1	2.3	0	102.9
1918-19.....	0.2	3.5	20.0	24.1	2.8	20.5	19.7	10.1	2.7	0.3	103.4
1919-20.....	0.2	8.2	19.9	13.5	7.7	13.5	17.1	20.6	1.9	T.	89.7
1920-21.....	0.1	16.7	4.3	19.2	12.7	10.1	9.4	15.3	1.9	T.	77.6
1921-22.....	0	2.4	2.8	11.9	21.0	14.6	16.0	5.2	3.6	0.1	96.9
Average..	0.6	5.6	8.7	15.8	15.8	16.2	15.8	13.2	4.9	0.3	96.9

Combined average for drainage basin in Colorado and New Mexico.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Season.
1909-10.....	0.6	3.8	15.6	19.8	13.4	15.1	7.1	7.5	1.5	0.0	84.4
1910-11.....	0	7.5	6.8	11.9	11.1	29.3	9.0	4.2	0.5	0	119.3
1911-12.....	0	9.6	16.0	14.4	8.0	10.4	36.5	19.5	6.3	0.6	83.7
1912-13.....	0.1	6.5	4.5	6.6	13.7	25.3	18.7	8.2	0.1	T.	103.3
1913-14.....	5.4	1.5	11.2	27.9	13.0	9.0	10.9	19.0	5.4	T.	109.8
1914-15.....	0.5	5.3	0.3	18.7	15.0	23.5	12.0	15.4	15.7	2.9	122.2
1915-16.....	0.4	1.2	7.2	20.4	44.9	7.5	18.1	19.9	2.6	T.	113.3
1916-17.....	T.	4.7	2.0	10.5	13.4	16.6	14.4	21.2	19.3	0	70.2
1917-18.....	0.2	0.9	2.2	1.1	25.2	15.2	17.0	10.1	2.3	0	102.9
1918-19.....	0.2	3.5	20.0	24.1	2.8	20.5	19.7	10.1	2.7	0.3	103.4
1919-20.....	0.2	8.2	19.9	13.5	7.7	13.5	17.1	20.6	1.9	T.	89.7
1920-21.....	0.1	16.7	4.3	19.2	12.7	10.1	9.4	15.3	1.9	T.	77.6
1921-22.....	0	2.4	2.8	11.9	21.0	14.6	16.0	5.2	3.6	0.1	96.9
Average..	0.6	5.6	8.7	15.8	15.8	16.2	15.8	13.2	4.9	0.3	96.9

TABLE 2.—Monthly discharge, in acre-feet, of Rio Grande, near Buckman, N. Mex. (given to hundreds only, units and tens rounded off).

Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Annual.
1909-10.....	898	2,030	812	291	355	374	313	2,000	3,050	4,260	1,300	110	15,793
1910-11.....	221	118	187	338	323	477	415	916	1,500	4,090	3,400	500	15,375
1911-12.....	695	643	3,360	1,320	775	489	428	947	1,390	7,010	1,940	683	19,677
1912-13.....	530	383	382	353	325	338	359	489	1,460	1,800	1,120	378	7,947
1913-14.....	168	258	499	483	352	294	428	916	1,640	3,710	2,530	1,160	12,448
1914-15.....	1,170	832	873	560	304	284	310	432	1,160	2,390	2,560	915	11,901
1915-16.....	712	434	399	355	387	441	499	1,940	2,660	5,100	3,250	985	17,569
1916-17.....	1,320	507	316	948	556	421	415	648	1,630	1,204	550	1,960	16,391
1917-18.....	376	278	248	374	352	327	326	678	714	1,530	1,300	650	7,533
1918-19.....	264	188	168	232	445	357	336	822	1,560	700	010	1,380	15,082
1919-20.....	889	361	533	539	541	485	777	858	1,420	3,600	7,050	1,840	23,890
1920-21.....	597	373	497	625	494	451	471	1,020	723	5,996	720	1,080	15,600
1921-22.....	1,320	947	474	493	538	535	502	761	1,070	4,010	3,690	820	15,762
Mean.....	751	566	664	535	446	405	429	963	1,659	4,202	3,191	1,189	15,000

<sup>1</sup> Incomplete.

TABLE 3.—Annual discharge of Rio Grande, near Buckman, N. Mex. (August to July), in thousands of acre-feet.

[Add three ciphers to figures in table.]

Year.	Dis-charge.	Snowfall (inches).
1895-96.....	852	.....
1896-97.....	1,708	.....
1897-98.....	1,240	.....
1898-99.....	652	.....
1899-1900.....	762	.....
1900-1.....	816	.....
1901-2.....	478	.....
1902-3.....	1,666	.....
1903-4.....	270	.....
1904-5.....	2,462	.....
1909-10.....	1,579	84.4
1910-11.....	1,538	80.4
1911-12.....	1,968	119.3
1912-13.....	795	83.7
1913-14.....	1,255	103.3
1914-15.....	1,190	109.8
1915-16.....	1,757	122.2
1916-17.....	1,639	113.3
1917-18.....	753	70.2
1918-19.....	1,509	102.9
1919-20.....	2,389	103.4
1920-21.....	1,560	89.7
1921-22.....	1,576	77.6
Mean.....	1,322	96.9